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Cement Slurry for cementation of wells subject to High Temperature with addition of Silica Flour and Metakaolin

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Abstract – This work analyzes the influence of different concentrations of silica flour and metakaolin addition in cement slurry for cementation of oil-wells subject to high temperature and pressure. One observes these materials show a silicate formation resistant to high temperatures (fig. 1), what makes possible to use them as additive to face retrogression if they are employed under concentration of 40%.

Cement materials change their physical, chemical and mechanical behavior if they are subject to high temperature and pressure. These changes are related to the convert of the hydrated phases to the cement slurry due to the transformation of the hydrated calcium silicate (C-S-H) in C-S-H phases with high relative calcium/silica, causing decrease of the resistance to compression named retrogression. According to Luke [1], the condition of formation and stability of hydrated calcium silicate in cement slurry for high temperature and pressure oil-wells is very significant to resistance and durability of the cement. To minimize this effect, one adds mineral additives with high concentration of silica, what favors to arise C-S-H phases which are rich in silica, and more stable in high temperatures, what maintains the integrity of the cement past placed on the annular and, consequently, prevents corrective cementations.

This work evaluates the influence of different concentrations of silica flour and metakaolin addition in cement slurry for cementation of oil-wells subject to temperature of 280°C, and pressure of 6,5 MPa, ordinarily employed in steam injections for oil thermal recuperation. It was prepared cement slurry to reach density of 1,90 g/cm^3 (15,6 lb/gal) with silica flour at 15 and 40%, and metakaolin at 20 and 40%, and a third one without addition. The cement slurry were mixed in a palette mixer with speed controller, and it was molded samples with dimensions of 5cm x 5cm, which were subject to a temperature of 280ºC for 3 days in a pressure cure room after previous cure for 28 days at 38ºC. The cement slurries were tested under simple compression, and it was also collected samples to x-ray diffraction tests.

It was observed that cement slurry with silica at 40%, and metakaolin at 20 and 40% maintained high levels of resistance to compression if subject to a temperature of 280ºC. Otherwise, this did not occur considering lesser addition and the reference slurry. Resistance is related to the hydrated phases present in the slurry. The reference cement slurry shows portlandite peaks and calcium chondrodite peaks ($Ca_5.[SiO_4]_2.(OH)_2$) and ($Ca_2.SiO_4.(H_2O)$) which are phases rich in calcium with relation Ca/Si of 2,5 and 2,0, respectively. Cement slurry with silica flour at 40% and metakaolin at 20 and 40% showed hydrated calcium silicate in variety of xenotlite ($Ca_6.Si_6O_{17}.(OH)_2$) and tobermorite ($Ca_5.(Si_6)O_{16}.(OH)_2$) which are more stable and resistant calcium silicates as it was proved through resistance to compression.

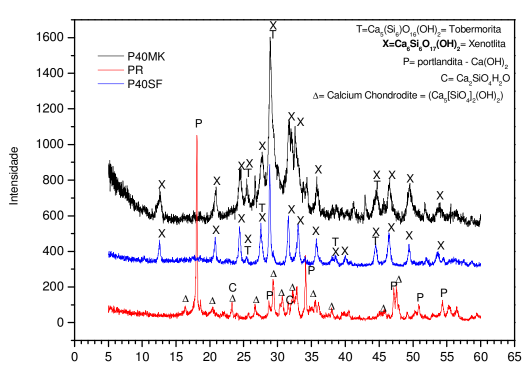

Fig. 1: Hydrated cement slurry DRX after cure at 38^o for 28 days, and 3 days at 280^{o}C

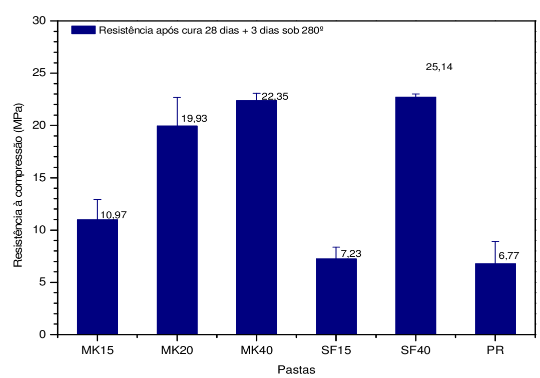

Fig. 2: Hydrated cement slurry resistance after cure at at 38^o for 28 days, and 3 days at 280^{o}C

[1] LUKE, K. "Phase studies of pozzolanic stabilized calcium silicate hydrates at 180ºC." Cem and Conc Research, 2004: 1725-1732.